DAIMLERCHRYSLER

Opportunities for Technology and Market Changes to Reduce Energy Intensity in the U.S. Economy

Bernard Robertson

Senior Vice President

Engineering Technologies and Regulatory Affairs

MAY 16, 2002

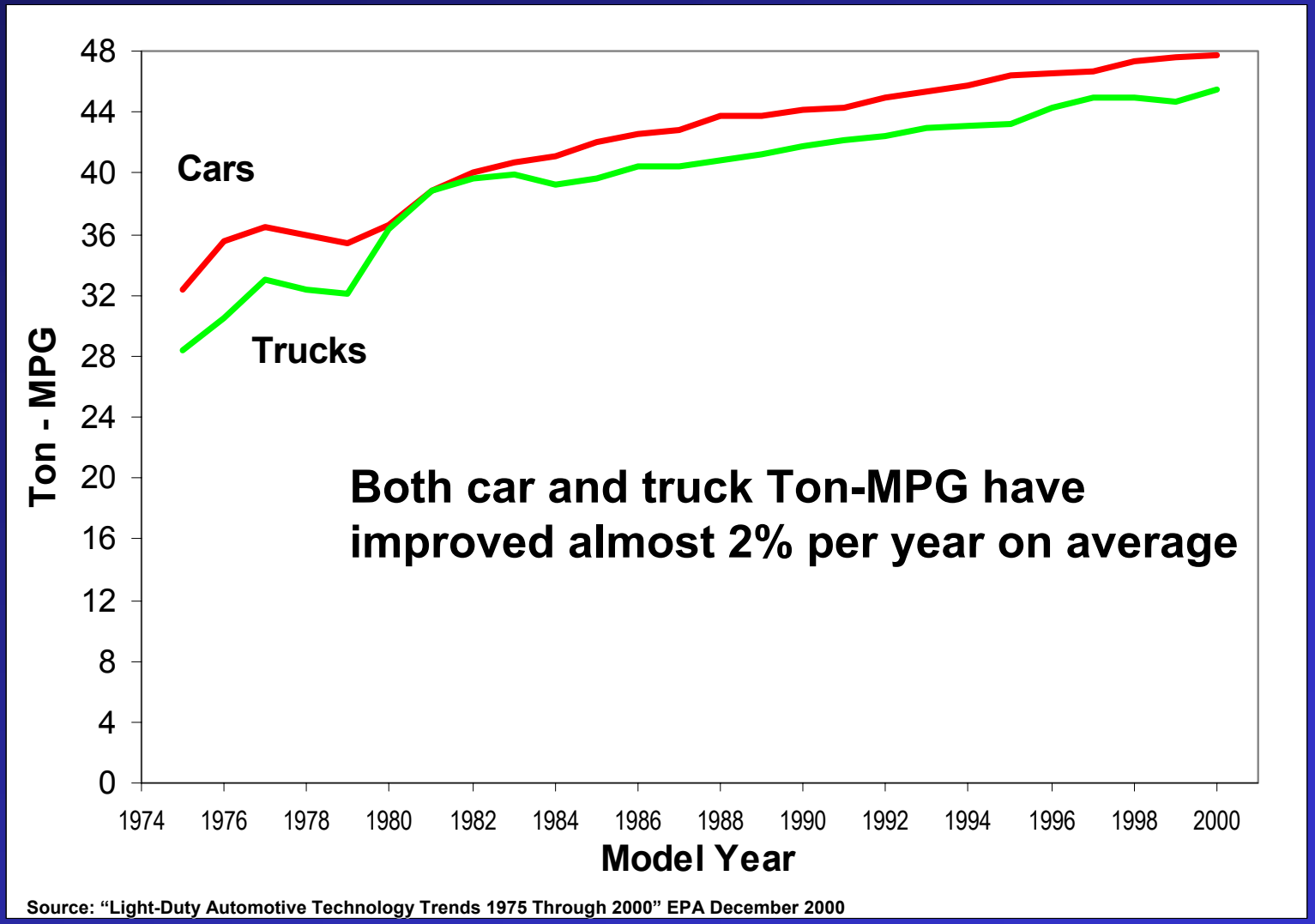
The Promise of Technology, Limits of Technology and Market Acceptance

- Energy Intensity Reduction Objectives, Targets, and Strategies
- Fuel Economy Progress
- Future Fuel Economy Technologies
  - Near Term
  - Medium Term
  - Long Term
  - Dependence on Objectives and Targets
- The Free Market, as Expressed by Customer Choices Needs to be Part of the Equation
  - Customer Values
  - Conflicting regulatory demands
- Conclusions

Energy Intensity Reduction Objectives, Targets, and Strategies

- The Energy Intensity Objective is critical to establishing goals and strategies
  - CO_2 Emission Reductions?
  - Independence from foreign oil?
  - Replacement of petroleum as it is depleted worldwide?
- The target needs to be clearly defined, scientifically based, and achievable
  - Stabilize atmospheric CO_2 at 500ppm? Pre-industrial levels?
  - Reduce U.S. imports to 40%? …20%? …0%?
- Appropriate strategies, including transportation technologies, can then be appropriately judged. Certain solution sets may be found to be applicable only to certain objectives and targets

Today's Vehicles are More Fuel Efficient

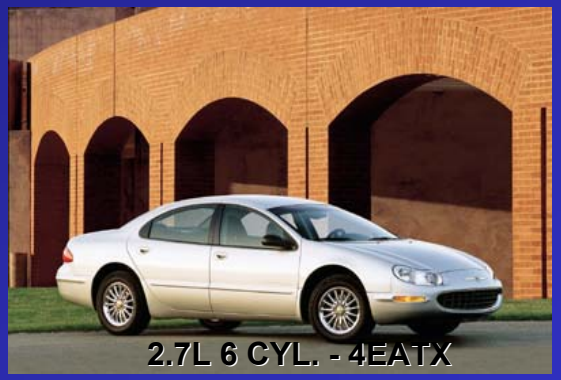


Source: "Light-Duty Automotive Technology Trends 1975 Through 2000" EPA December 2000

Large Car Utility and Performance at Sub-Compact Car Fuel Economy Levels

1978 Dodge Omni

2001 Chrysler Concorde



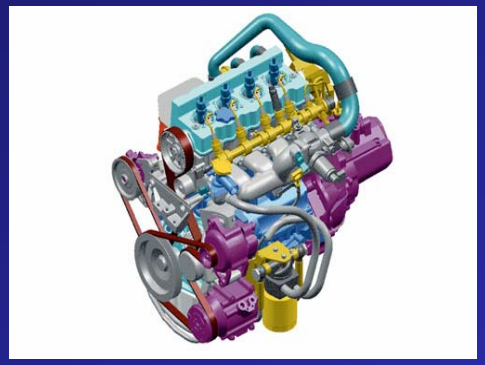
- Increased safety content (air bags, energy absorption..)
- Emissions reduced 95% (EPA75 to NLEV)
- Increased interior volume by 21 %
- Improved unadjusted combined fuel economy (Omni 26.2 MPG vs. Concorde 26.4 MPG)

Near-, Mid-, and Long-Term Technologies

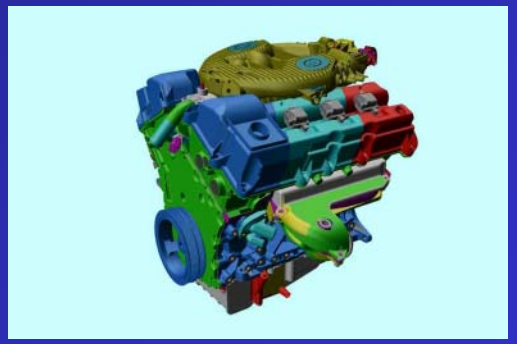
- Vehicle Fuel Economy Technologies
  - Near-term are generally incremental improvements on existing internal combustion engines
  - Mid-term technologies deploy existing ICE technologies in new contexts. The most publicized being hybrids
  - Long-term technologies contemplate entirely new approaches to motive power -- EVs, Fuel Cells, the "Hydrogen Economy"
- The nature and magnitude of the objectives and targets will determine whether these routes should be pursued
- Resources will not permit developing all three approaches, if one is identified as the necessary solution
- A business case must be developed for the deployment of any technology. Along with our social responsibilities to the environment and safety, and our need to satisfy customers, we must realize a reasonable return to our investors. Customers must demand, and be willing to pay for fuel economy-enhancing technology

Near Term: Advanced Technology

Manufacturers must try to identify which promising new technologies will win in the marketplace, given objectives which call for historical, incremental improvements in efficiency on the order of 1-2%/year

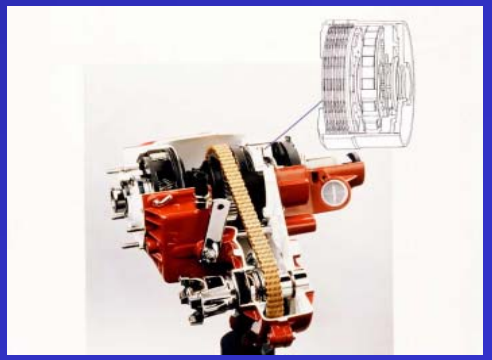


1.9L Turbo Diesel



Direct Injection Gasoline

EMAT Electro-Mechanical Automatic Transmission



Improved Drivelines

Near Term Technologies

- Variable Valve Timing and Lift
- Multiple Displacement Systems
- Idle Stop/Start Systems
- Gasoline Direct Injection
- Transmission Effects
  - Continuously Variable Transmissions (CVT
  - Electro-Mechanical Automatic Transmissions (EMAT)

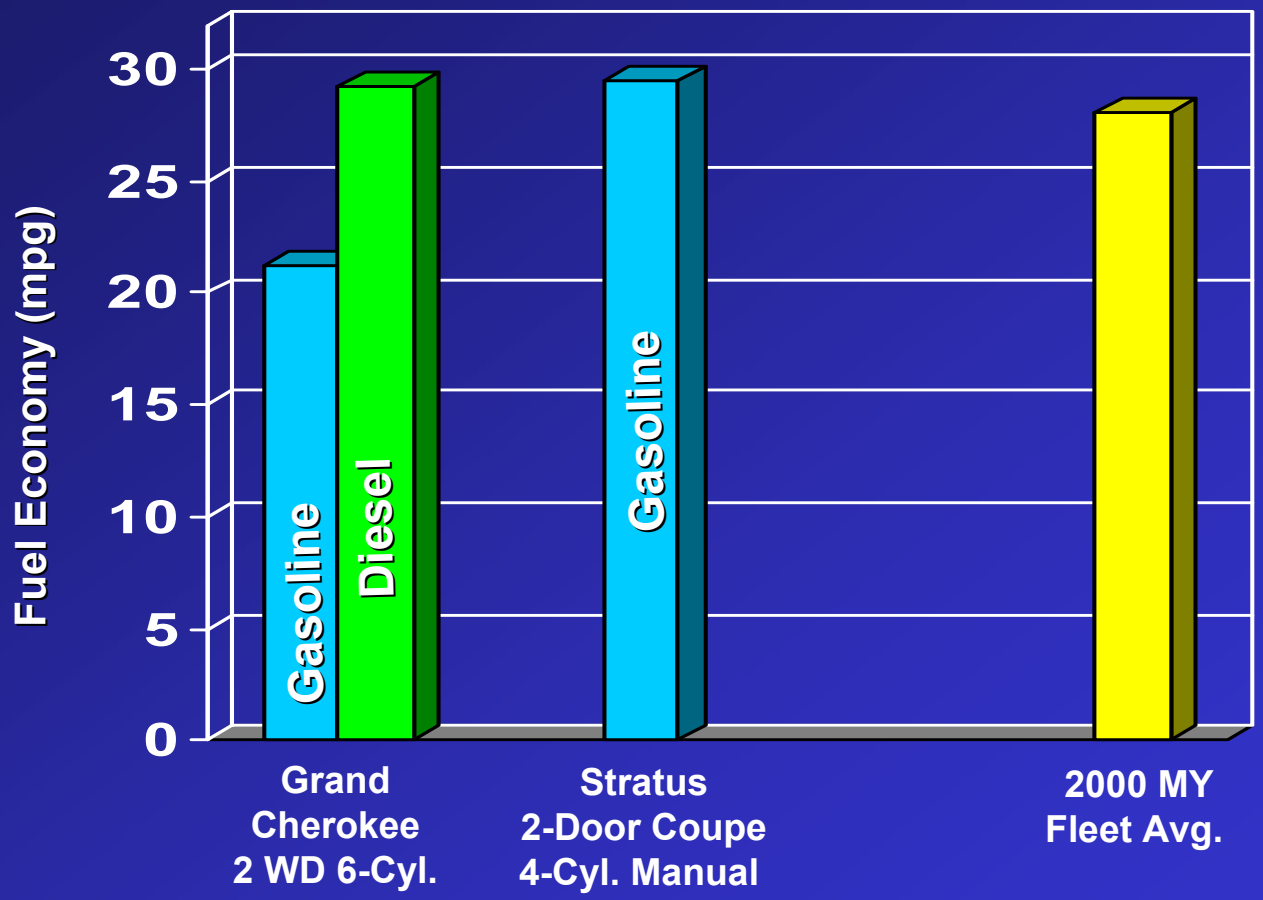
Benefits of Light Duty Diesel Vehicles

- Although a cost penalty compared to gasoline engines, diesel technology is more well developed and will be more affordable than hybrids or fuel cells in the near and mid-term
  - Advanced, fuel efficient light-duty diesels are available and well accepted in other developed markets around the world
  - If DaimlerChrysler had the same diesel market share in the U.S. as in the EU (40%), CAFE would improve by 3.0 mpg
- Given good fuel, advanced technology diesels offer the greatest potential for midterm CO_2 reductions
  - CIDI was the PNGV downselect technology, recognized by PNGV Peer Review, NAS and the Administration
  - European Auto Association (ACEA) anticipates 90% penetration of direct injection technology by 2008

Benefits of Light Duty Diesel Vehicles Conflicting U.S. Vehicle Emissions Standards

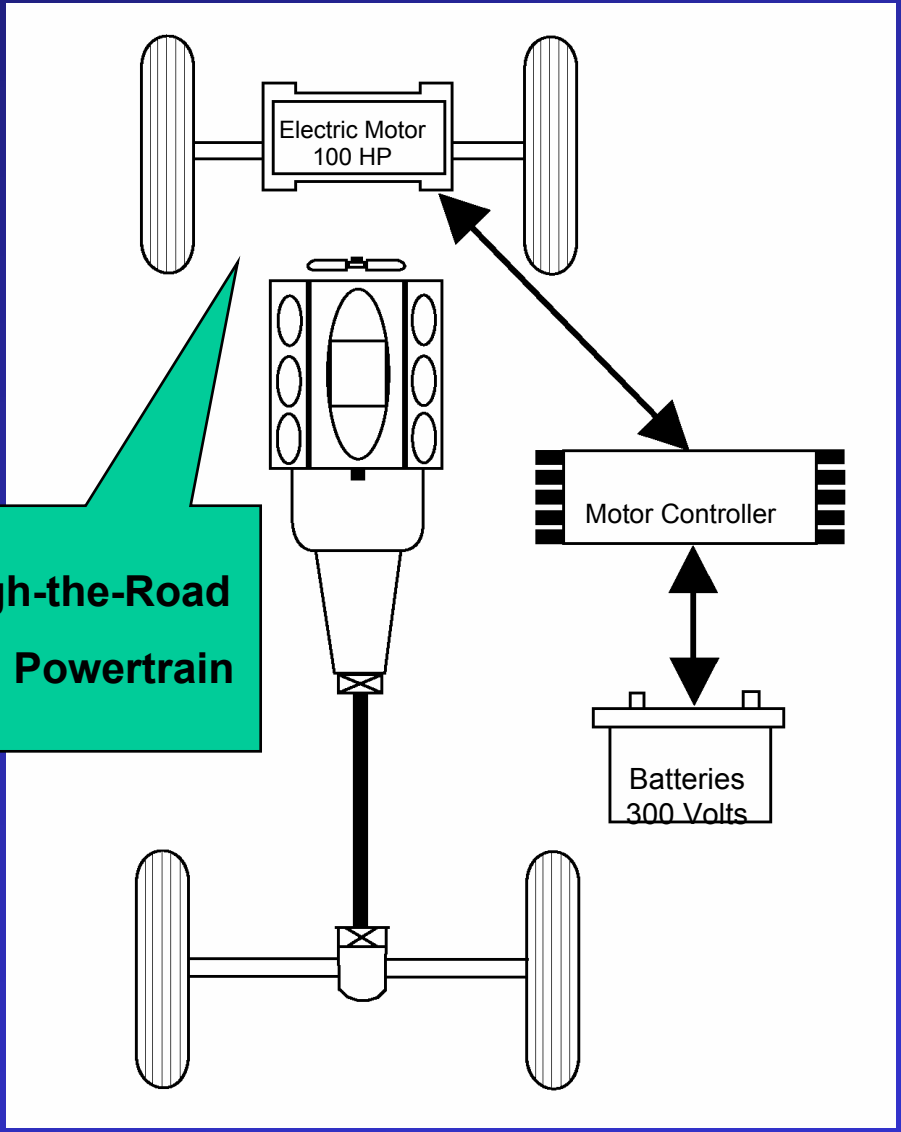
- While the modern, common rail, electronic direct injection diesel engine has found widespread popularity in Europe, its introduction in the United States faces serious questions due to extremely strict NOx standards
  - While these standards are not achievable in a practical fashion today, significant work toward a NOx breakthrough is ongoing
- This is a good example of conflicting societal goals.
  - Fuel Economy?
  - NOx Reductions?
- Europe has temporarily accepted less stringent NOx standards in order for diesels to play a role in increasing fuel economy and lowering CO_2 emissions
- A fundamental question, beyond fuel economy, and emissions, is: "Will the American public embrace the diesel?" Can we build a business case for volume production production of diesel-powered light duty vehicles?

Diesel Grand Cherokee SUV Matches Stratus Compact Car Fuel Economy



Medium Term: Hybrid Electric Vehicles

- DaimlerChrysler is prioritizing HEV technology on vehicles that customers will accept
- Fuel savings do not pay back hardware without tax incentives
- Incentives for advanced technology would promote initial customer acceptance
- Whether or not to pursue this route depends on the magnitude and timing for energy savings, and whether customers will pay for the cost of this technology…again: Is there a business case?



Commercially Based Tactical Truck - ComBaTT

based on 2001 Dodge Ram

- Hybrid Electric Vehicle for the U.S. Military
- 4WD, 5.9 L Turbodiesel, with integrated 35kW electric Traction Motor
- Generator provides up to 20 kW @ 60 Hz AC
- Traction Assist, Regenerative Braking, Silent AC Power Generation, Improved Fuel Economy, Enhanced off-Road and Structural Features
- Limited Range of “Stealth” operation on electric power
- The Business Case Exists, at least for limited production

The biggest question around fuel cell vehicles is not the fuel cell, but the fuel

- Fuel Cells run on hydrogen
- The source of the hydrogen requires a balance between distribution, on-board storage, and on-board processing
- The use of hydrogen in internal combustion engines may spur the development of the hydrogen distribution infrastructure, and serve as a bridge between the technology of today, and that of tomorrow.
- Several Hydrogen sources which have been evaluated include
  - Pressurized or liquified hydrogen stored on-board
  - Methanol for reforming
  - Gasoline for reforming
  - DaimlerChrysler has shown that materials not normally considered as fuels can be used to generate hydrogen on board as demonstrated in the sodium borohydride powered Natrium Minivan

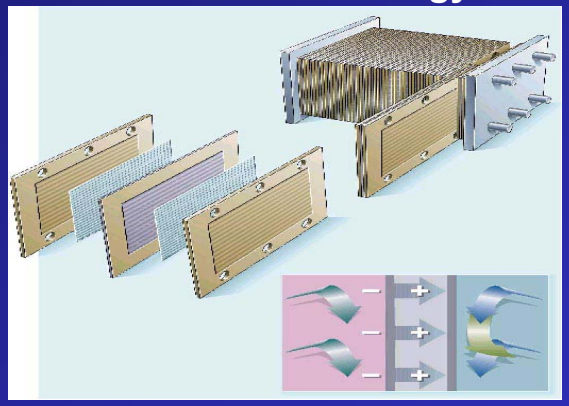
Fuel Quality

- Regardless of the ultimate vehicle technology "winner", fuels must advance with vehicle technology
  - The essence of quality (reliable emissions reductions) is a reduction in variability around a desired value
  - For "conventional" fuels, this means consistent near-zero sulfur, a very narrow range in volatility, high and consistent octane or cetane, a consistent level of elements other than carbon and hydrogen
    - Dealing with E-0, E-10, E-22 (Brazil), and E-85 will likely lead to non-optimal solutions for at least one of these fuels
  - Appropriate fuel properties for alternative and renewable fuels have yet to be defined
    - What contaminants are important in bio-diesel? Does ASTM adequately define an appropriate acidity level in fuel ethanol? How pure will hydrogen need to be?

Long Term:
Fuel Cell Vehicles (FCVs)

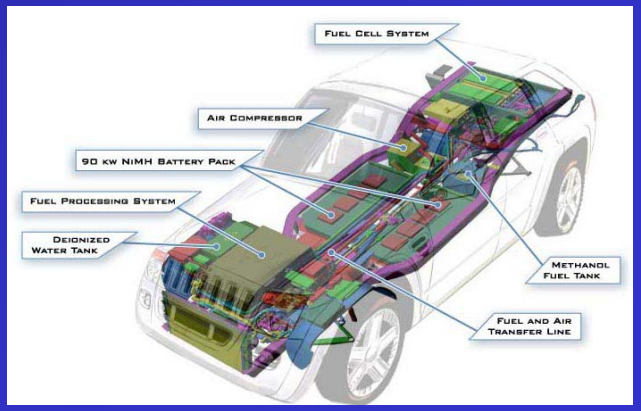
- While FCV market entry is anticipated in 2003/2004, volume production is at least ten years away, due to cost, complexity, and fuel infrastructure
- Internal combustion engine HEVs are at least a 10-year stop-gap solution and may co-exist with FCVs long term, however, a clear definition of our energy saving targets may favor one over the other

Fuel Cell Technology

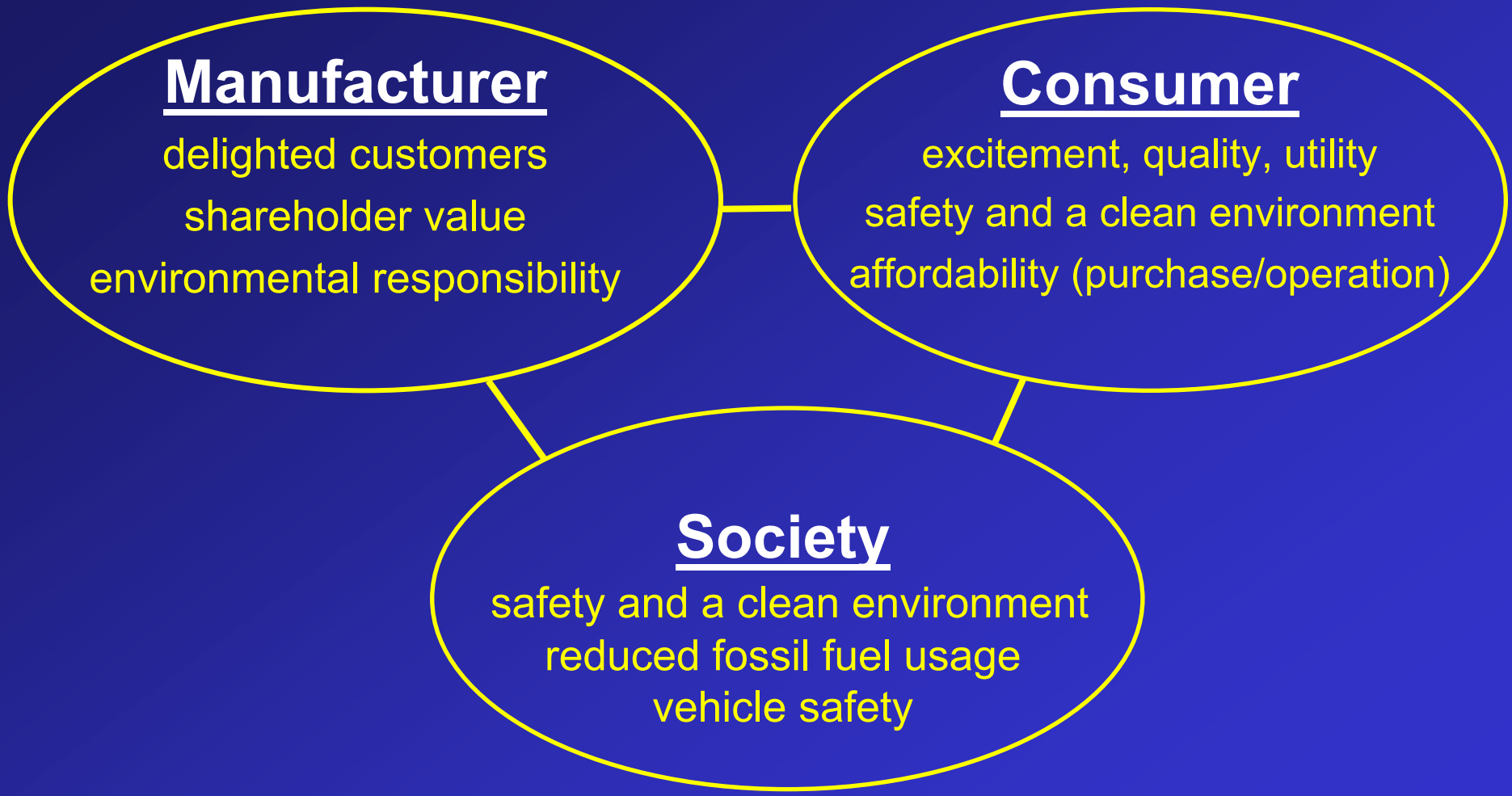


necar 4 Fuel Cell Vehicle

Commander 2 Fuel Cell Vehicle

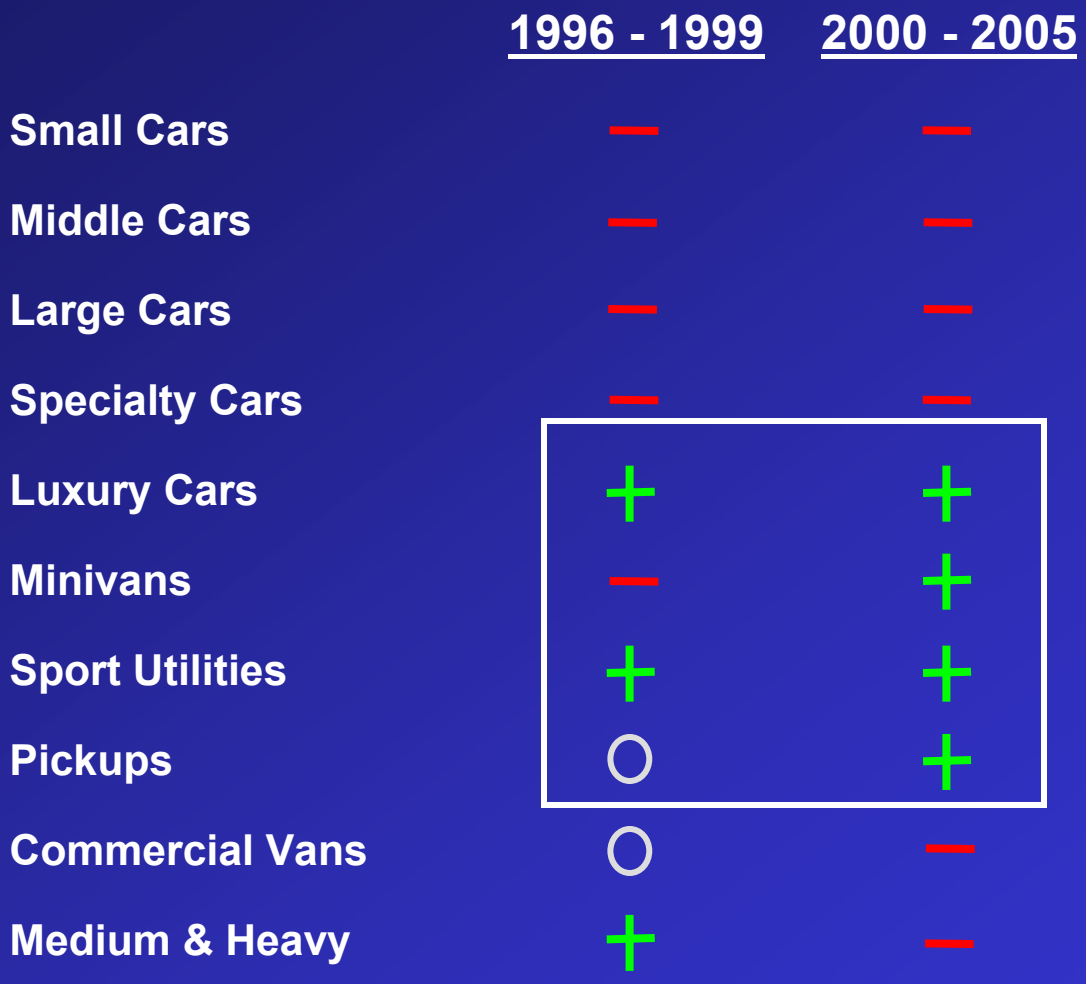


Overlapping and Sometimes Competing Goals



Changing Market Segments

NAFTA



Consumers are Demanding Additional Equipment ...

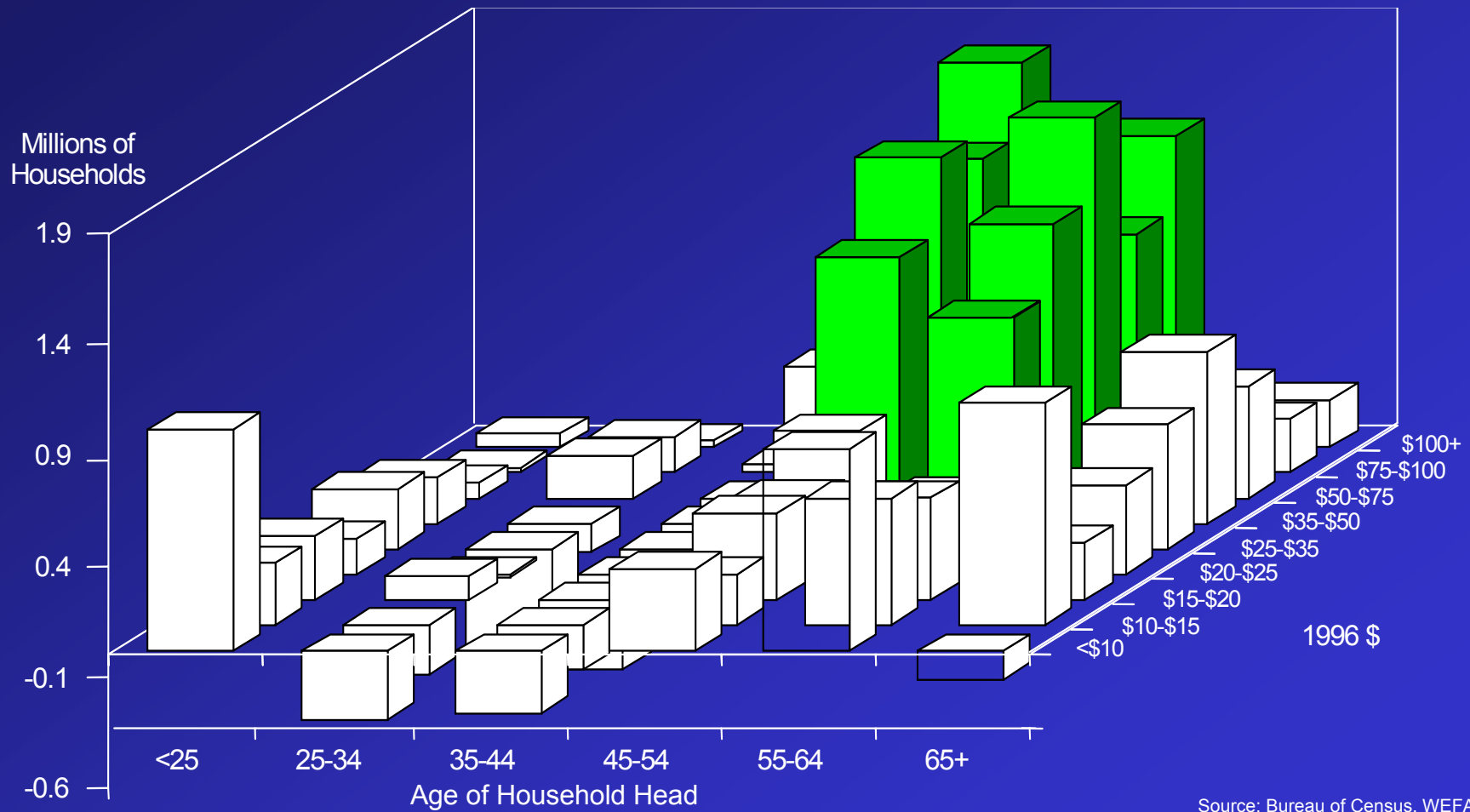
Percent of U.S. New Car Sales

	Model Years		
	1974	1987	1999
Power Door Locks	12%	48%	86%
Power Windows	19	45	83
Power Seats	11	30	42
Air Conditioning	68	85	98
Adj. Steering Column	19	71	92
Rear Window Defogger	22	74	95
Cruise Control	12	62	79
Traction Control	4	8	26
Anti-lock Brakes	0	4	65
Air Bags	0	0	100
Keyless Remote	0	--	58
Anti-theft Device	0	--	29

Source: Wards Automotive Yearbook

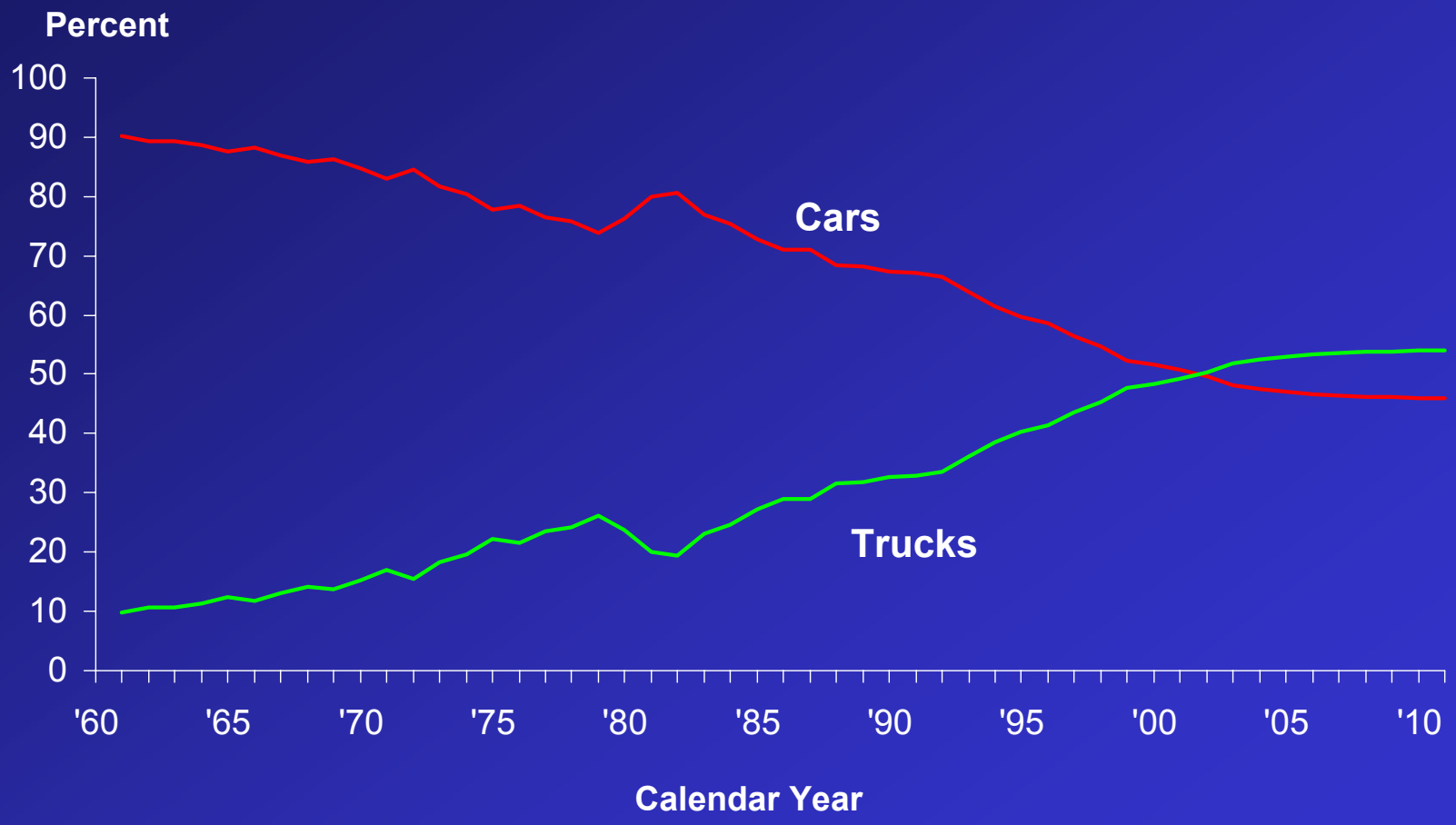
Consumers are Becoming Older and More Affluent

Change in Number of Households, 1995 to 2010

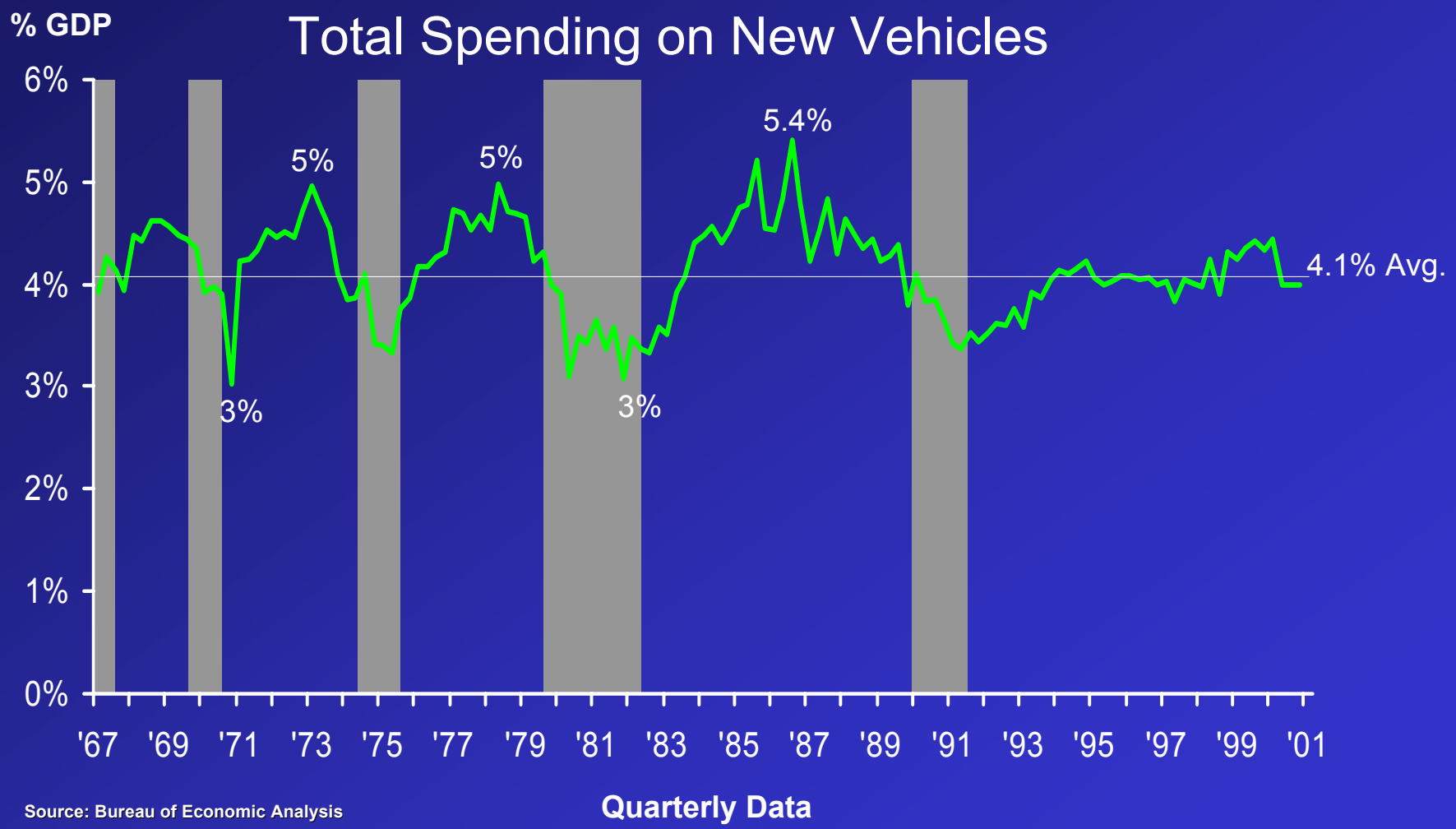


Source: Bureau of Census, WEFA

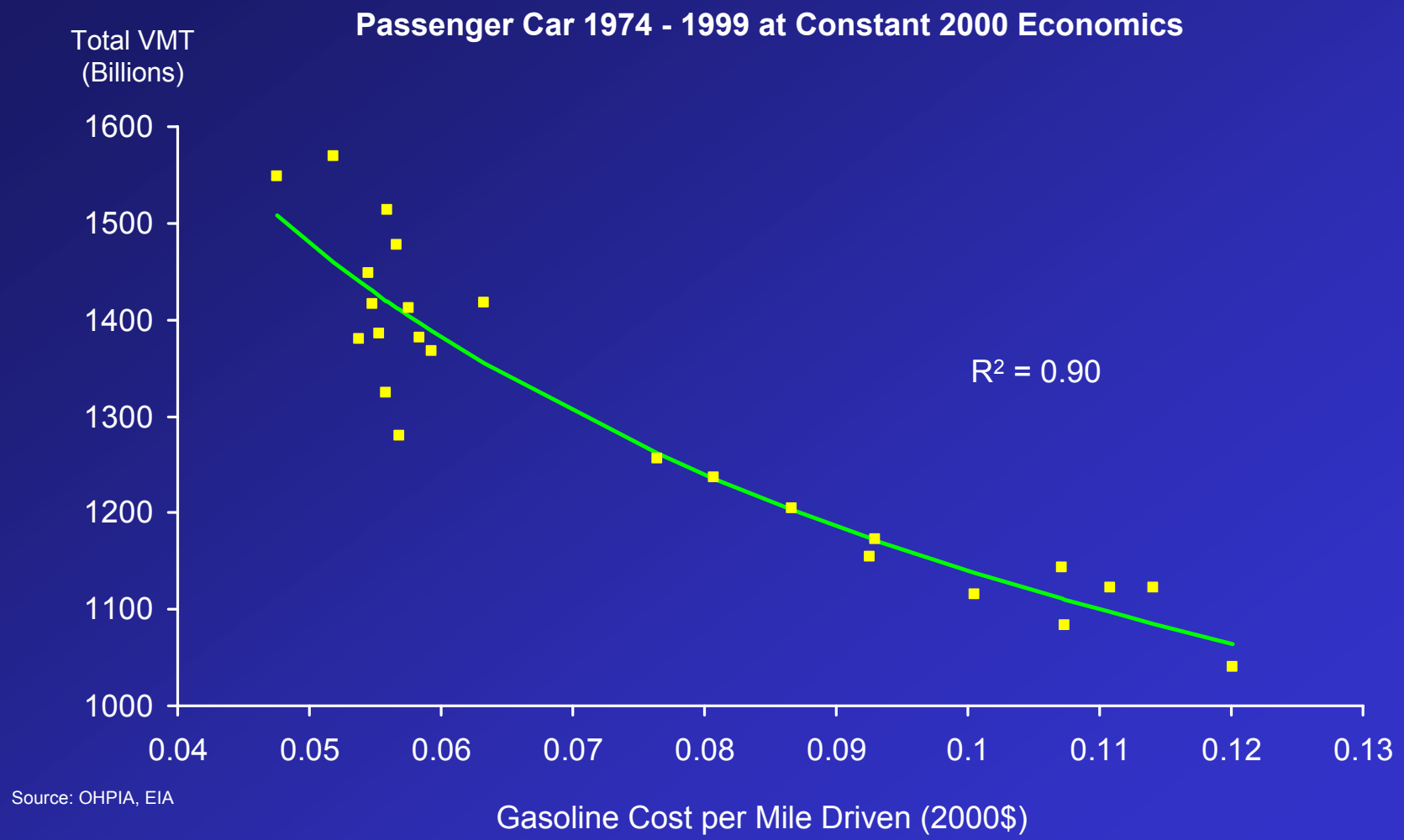
Car/Truck Mix
U.S. Light Vehicle Industry Sales



... However, Consumers do not Want to Pay More for It



Consumers Drive More Miles When Driving Is Cheap



Source: OHPIA, EIA

Conclusions

- **Energy Policy formulation should be preceded by clear definition of objectives and targets**
  - **Energy Objectives and Targets will drive technology deployment . In the absence of clear objectives and targets, wrong approaches may be pursued, resources will be wasted. For instance, if a scientific analysis determines that carbon free transportation is eventually essential, then the intermediate phases of incremental improvements to ICEs or hybrids may not be cost effective**
- **Customer expectation cannot be ignored as a driving force in the automobile market**
- **Advanced technology is the only opportunity for improved fuel economy that is actionable by automakers**
- **The promise of technology is constrained by cost and conflicting requirements, primarily regulatory. Any deployment of advanced fuel efficiency technology must be demanded by customers, so that carmakers can build a solid business case for investors**